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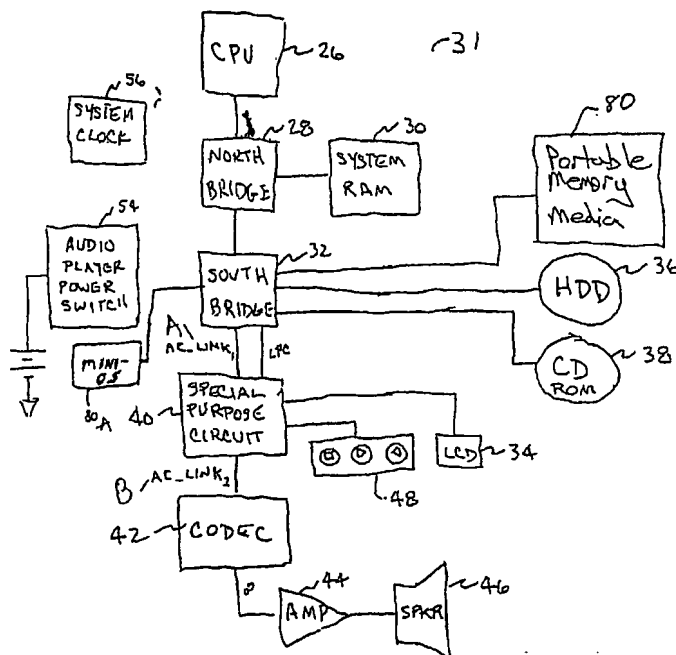
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- (71) Applicant: O2 MICRO INTERNATIONAL LIMITED
[—/—]; P.O. Box 32331 SMB, Grand Cayman (KY).
- (72) Inventors: LAM, James; 34760 Swain Common, Fremont, CA 94555 (US). IVCHENKO, Volodymyr; 1560 San Tomas Aquino Road, #5, San Jose, CA 95130 (US).
- (74) Agents: PFLEGER, Edmund, P. et al.; Hayes, Soloway, Hennessey, Grossman & Hage, P.C., 130 W. Cushing Street, Tucson, AZ 85701 (US).
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(54) Title: LOW POWER DIGITAL AUDIO DECODING/PLAYING SYSTEM FOR COMPUTING DEVICES



(57) Abstract: A low-power digital audio decoding and playing system and method for computing devices provides a low-cost, low power-consumption, long-battery-life audio playing and decoding system, which may be used to play compressed audio files of various formats. In one aspect, a computer system adapted to play audio files comprises a system CPU, memory, at least one drive comprising compressed audio data, and an audio controller coupled to the system CPU, memory and drive. The audio controller is adapted to cause the drive to read the compressed audio data from the drive, to cause the system CPU to decompress the compressed audio data from the drive into decompressed audio data, to cause the decompressed audio to be stored in the memory, and to cause the decompressed audio data to be retrieved from the memory for playing.

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1 **LOW POWER DIGITAL AUDIO DECODING/PLAYING SYSTEM**
2 **FOR COMPUTING DEVICES**

3 This application is a continuation-in-part of U.S. patent application no.
4 09/921,171 filed August 2, 2001 entitled "Low Power Digital Audio
5 Decoding/Playing System for Computing Devices", which claims the benefit of
6 provisional application serial No. 60/250,899, filed on December 1, 2000, entitled
7 "Low Power Digital Audio Decoding System for Computing Devices" and
8 provisional application serial No. 60/265,466, filed on January 30, 2001, entitled
9 "Low Power Digital Audio Decoding/Play System for Computing Machines".

10 **BACKGROUND OF THE INVENTION**

11 **1. Field of the Invention**

12 The present invention relates generally to portable devices (e.g., notebook
13 computers) for reproducing audio recordings, and more particularly, to low-power
14 hardware and software for decoding and reproducing compressed audio recordings in
15 a variety of compression formats from a variety of sources. While particular utility
16 for the present application is in the reproduction of MP3 digital audio files, especially
17 for use with portable computers, other utilities are contemplated herein.

18
19 **2. Description of Related Art**

20 Presently there exist various portable devices for replaying digital audio
21 recordings that have been compressed in accordance with one or more compressed
22 audio digital recording formats, e.g., MPEG (Moving Picture Experts Group) Audio
23 Layer-3 (MP3), Windows® Media Audio (WMA), and Advanced Audio Coding
24 (AAC). To date, the most popular format has been MP3, a compression scheme that
25 results in about a 10:1 compression of the size of digital music files. These devices
26 can be divided into two classes, those which store the compressed digital audio
27 recordings in an electronic solid-state memory, and those which record the
28 compressed digital audio for subsequent reproduction using an electro-mechanical
29 device such as a compact disk ("CD") player or on a hard disk drive of a digital
30 computer.

31 For example, portable devices for playing MP3 compressed digital audio

1 recordings that use electronic solid-state memory, e.g., flash-memory, are capable of
2 storing about ten (10) music selections. With an add-in memory card, such devices
3 can carry a total of about twenty (20) music selections. These MP3 players that store
4 the MP3 compressed digital audio recordings in an electronic solid-state memory
5 consume comparatively little electrical power. Thus, such MP3 players provide an
6 extended playing interval without having to power the computer's CD-ROM or hard
7 disk drive.

8 U.S. Patent No. 6,226,237, entitled "Low Power CD-ROM Player for Portable
9 Computers", issued May 1, 2001 (the "'237" patent), which is hereby incorporated by
10 reference in its entirety, describes how a conventional notebook computer, when
11 simply playing a conventional music CD, consumes an unnecessarily large amount of
12 electrical energy. That is largely due to the large number of background functions
13 that are unrelated to the playing of music that the Operating System (e.g., Windows®)
14 is performing whenever the computer is turned on. That excessive electrical energy
15 consumption for functions unrelated to the function the user is performing at the
16 moment, i.e., playing music, quickly drains the battery of a notebook computer of
17 power that could more prudently be applied at another time in performance of
18 microprocessor intensive tasks such as word processing and spreadsheet analysis.
19 The solution presented in the '237 patent is a state machine that operates when main
20 power to the portable device is OFF. The invention of the '237 patent couples a CD-
21 ROM to the audio subsystem (when main power is OFF) so that CDs can be played,
22 without excessive battery drain, or without having to boot up the portable computer.

23 The prior art also includes silicon solutions that are dedicated function
24 integrated circuits (ICs) or incorporated into application-specific integrated circuits,
25 or ASICs. These are usually expensive solutions as the digital signal processor (DSP)
26 required in a dedicated chip results in a large, costly integrated circuit. One of the
27 results is the use of a larger amount of PCB (printed circuit board) space.

28 Further, the 15 to 20 MIPS (million instructions per second) decode engine
29 known in the art must be continuously running to generate the audio stream for the
30 Codec. Additionally, the dedicated decode engine needs to have the high-power-
31 consuming hard disk drive (HDD) continuously operating. These approaches are

1 limited to functioning only with MP3 compression, thereby eliminating the
2 opportunity to adapt the system to newly emerging music compression algorithms,
3 such as Microsoft's WMA or the music industry's proposed Secure Digital Music
4 Initiative (SDMI) for secure audio.

5 Dedicated silicon solutions known in the art employ a DSP that must
6 constantly be decoding the compressed audio files from a hard disk drive, which must
7 therefore be constantly reading the audio files. Such known methods require much
8 power, resulting in a fast battery discharge, (e.g., much faster than the possible 4 to 10
9 hours of desired use on a transoceanic flight).

10 Thus, known hardware MP3 decoder and players requiring an IC
11 implementation and a hard disk drive being accessed non-stop are high in power
12 consumption, difficult to upgrade, and expensive.

13 The present invention provides a solution that is low in power consumption,
14 can be upgraded in the field for various music compression formats, is expected to
15 cost no more than half the cost of the currently available hardware implementation,
16 and may be made capable of playing up to hundreds of musical selections, while only
17 having to access the HDD or CD-ROM less than 0.5% of the time.

18 SUMMARY OF THE INVENTION

19 It is becoming more and more desirable for mobile platform companies to add
20 MP3 and other compressed audio player capability to their products, with low cost,
21 while providing very long music playing time, and perhaps even a player that can be
22 later upgraded to other compression formats by the owner. These mobile platform
23 companies may also want to market differentiate their products within a very short
24 development time frame.

25 The music playing solution of the present invention utilizes a special purpose
26 circuit in combination with the mini-OS (operating system) software of the present
27 invention. The present invention uses the embedded computing power of the standard
28 CPU to perform the file decompression. Since today's CPUs with clock rates of 500
29 MHz to 1 GHz have at least an order of magnitude higher processing power than the
30 real time DSP engines used in currently available MP3 player/decoders, these
31 powerful CPU processors can often finish the decoding process in less than 10% of

1 the available time. The CPU may then be set to idle by the present invention for more
2 than 90% of the time, saving large amounts of power and thus greatly slowing the
3 discharge of the battery and extending the useful time of the equipment under battery
4 power on a single charge.

5 The present invention is unlike the real-time DSP engines known in the art,
6 which require a constant data stream from the HDD, and which result in high power
7 consumption, since the HDD is being accessed all the time. Using the technology of
8 the present invention, the HDD may be accessed less than 0.5% of the time with a
9 typical complement of memory, i.e., 128MB RAM. This results in a dramatic
10 reduction in the rate at which power is dissipated from the equipment battery.
11 Further, minimal PCB changes are required for the present invention, thus resulting in
12 the quick adoption of new product features in PCs.

13 There are many possible music compression algorithms. Compression
14 algorithms other than MP3 include WMA, AAC, and the proposed SDMI. The
15 software decompression methodology of the present invention can be easily modified
16 to decode any compression scheme, or with a software installation process, all the
17 various compression schemes. This flexibility allows the adaptation to new and
18 different algorithms, as they become popular, by permitting an after-market upgrade
19 of computers equipped with the present invention. Also, since this portion of the
20 present invention is a software system, new updates and/or algorithms may be
21 downloaded (e.g., from the Internet) to upgrade machines in the field, eliminating the
22 necessity for consumers to buy multiple players/decoders in order to listen to audio
23 files having different compression formats.

24 Thus, the present invention provides a low-cost, low power-consumption,
25 long-battery-life audio playing and decoding system, which may be used to play
26 audio files of various formats.

27 In one aspect, a computer system adapted to play audio files comprises a
28 system CPU, memory; at least one drive comprising compressed audio data residing
29 in one or more audio files, a play list software program for selecting and storing a
30 play list comprising one or more of the audio files, a first operating system adapted to
31 control at least the system CPU and memory, and a second operating system stored in

1 BIOS and adapted to retrieve the play list and cause the drive to read at least one
2 audio file of the play list, to cause the system CPU to decompress the compressed
3 audio data of the file and provide decompressed audio data, and to cause the
4 decompressed audio data to be stored in memory.

5 In another aspect, a computer system adapted to play audio files comprises a
6 drive comprising at least one audio file, an audio controller, and an operating system
7 stored in BIOS, the operating system controlling the audio controller, so as to cause
8 the audio controller to play at least one audio file.

9 In a further aspect, a computer system adapted to play audio files comprises:
10 compressed audio data, a system CPU, an audio controller, a first operating system
11 adapted to control at least the system CPU, a second operating system controlling the
12 audio controller and system CPU, so as to cause the system CPU to decompress the
13 compressed audio data, and a switch, the activation of the switch causing the second
14 operating system to boot.

15 In yet another aspect, a computer system adapted to play audio files comprises
16 a system CPU, memory, at least one drive comprising compressed audio data residing
17 in one or more audio files, a play list software program for selecting a play list
18 comprising one or more of the audio files, and an audio controller coupled to the
19 system CPU, memory and drive. The audio controller is adapted to cause the drive to
20 read at least one audio file of the play list, to cause the system CPU to decompress the
21 compressed audio data of the file and thereby provide decompressed audio data, and
22 to cause the decompressed audio data to be stored in memory.

23 In process form, a method of playing audio files on a computer system
24 comprises: booting a first operating system; creating and storing a play list
25 comprising a list of compressed audio files residing on one or more drives of a
26 computer system having at least a drive, a CPU, and a memory; terminating the first
27 operating system; booting a second operating system upon activation by a switch;
28 reading the play list; reading the compressed audio files from the drive based on the
29 play list; providing the compressed audio data to the CPU for decompressing the data
30 of the compressed audio file into decompressed audio data; storing the decompressed
31 audio data in memory; and retrieving the decompressed audio data from the memory

1 for playing.

2 In another process form, a method of playing audio files on a computer system
3 comprises: reading compressed audio data from the drive of a computer system
4 having at least a drive, a CPU, and a memory; providing the compressed audio data to
5 the CPU for decompressing the compressed audio data, thereby providing
6 decompressed audio data; and storing the decompressed audio data in memory.

7 **BRIEF DESCRIPTION OF THE DRAWINGS**

8 Figure 1 is a block diagram representation an exemplary operational flow of
9 one embodiment of the present invention;

10 Figure 2 is a flow diagram of an exemplary power up of the mini-OS and
11 initiation of the player function, in one embodiment of the present invention;

12 Figure 3 is a block diagram of an exemplary audio player system consistent
13 with one embodiment of the present invention;

14 Figure 4 is a block diagram of the internal portion of an exemplary special
15 purpose circuit, in relation to the other components that interface with it, in one
16 embodiment of the present invention; and

17 Figure 5 is another block diagram of an exemplary audio player system
18 consistent with another embodiment of the present invention.

19 **DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS**

20 The present invention comprises mini-OS (operating system) software and a hardware
21 interface between the South Bridge and Codec to play the musical selections (or other
22 stored audio) desired by the user. The mini-OS software of the present invention
23 performs only those functions and enables those elements of the portable computer
24 that are needed, when they are needed, to play the selected music, without performing
25 all of the background functions performed by the full system operating system, e.g.,
26 Windows®, and without accessing the monitor circuitry and monitor screen of the
27 portable computer. Additionally, the mini-OS of the present invention only accesses
28 the HDD when compressed files are being transferred to RAM. Thus, it will be seen
29 that the mini-OS software portion of the present invention performs both power
30 saving and file management functions when playing audio.

31 Figure 1 is a block diagram representation of the operational flow of the

1 exemplary software compressed audio player in one embodiment of the present
2 invention.

3 The operational concept illustrated in Figure 1 is as follows:

4 1st: A browser, running on a full system operating system,
5 e.g., Windows®, of the portable computer is initially used to download
6 compressed music files (for example 1000 songs) onto the PC hard
7 disk drive (HDD) (2) (e.g., using 4 gigabytes of HDD space) at some
8 time prior to the time at which the user desires to use the portable
9 computer as an audio player and a playlist is created, comprising the
10 songs the user desires to hear at a later time;

11 2nd: When the user desires to use the portable computer as
12 an audio player, once the desired music files are on the HDD, the user
13 operates an audio player on-switch to turn the portable computer fully
14 on, boot up the entire computer, load in the mini-OS of the present
15 invention instead of the usual Microsoft Windows® OS (the full system
16 operating system is not opened) with the power saving initialization
17 subroutines and initializes only those portions of the portable computer
18 as necessary, and the file management subroutines initialize the song
19 play list or book generated in step 1, of a substantial number of songs,
20 for desired music listening under direction of the user;

21 3rd: The mini-OS software is then copied from the HDD (2)
22 to RAM (4), and then the first set of compressed files from the song
23 play list is copied from the HDD (2) to the system RAM (4) also using
24 the mini-OS software of the present invention. For example, in today's
25 PC's 128 Mbytes is a typical system RAM size, with the mini-OS
26 software of the present invention taking about 8 Mbytes of the RAM,
27 leaving approximately 120 Mbytes for use as a compressed music
28 memory (i.e., a cache or buffer, using system memory, dedicated
29 memory, or other memory). That 120 Mbytes represents about 2 hours
30 of continuous compressed music with a compression ration of 10:1,
31 typical of MP3 files. Similarly, in the case when flash media is used

1 for MP3 storage, all or most of the contents of the flash media card can
2 be copied to the system RAM (4), thus minimizing the access of the
3 flash media reader and allowing for a more responsive control over the
4 MP3 files;

5 4th: The file management software of the present invention
6 sequentially delivers portions of the first music file to the CPU (6)
7 where the decode algorithm decompresses each file using the file
8 management software of the present invention stored in RAM (4).
9 Once decoded, the PCM audio data is transferred in one of three ways:
10 the CPU delivers the PCM audio data to the South Bridge (see Figure 3
11 (32)) FIFO buffer; the DMA in the South Bridge transfers the data
12 internally within the South Bridge to the FIFO buffer; or the special
13 purpose circuit transfers the data to the FIFO buffer from the LPC
14 interface. The FIFO buffer then sequentially feeds each piece of
15 decoded music to Codec (8) (also see Figure 3 (42)), through the
16 special purpose circuit of the present invention, where the decoded
17 signal is converted from digital to analog. Then the output signal from
18 the Codec (8) is amplified (10) (also see Figure 3 (44)) to drive the
19 speakers and/or headset (see Figure 3 (46)).

20 5th: While the final song of the first set from the play list is
21 playing from memory, the file management software of the present
22 invention stored in the RAM (4, 30) returns control to the 4th step to
23 retrieve the next set of compressed music files from the memory of the
24 RAM, as determined by the earlier scripted song play list developed in
25 the 1st step. Thus, the 4th and 5th steps are repeated for each set of
26 compressed music files until the last music selection in the set plays.
27 At that point in time control returns to the 3rd step to load another set
28 from the play list, which is similarly played through the 4th and 5th
29 steps. When the last song is played from the overall play list of the 2nd
30 step, or when the user turns off the music player function, the
31 operation of the player ceases.

1 The mini-OS power saving software of the present invention ensures that the
2 CPU, Peripheral Chips, HDD and other controllable system elements will be in idle
3 state for the highest percentage time possible. An interesting attribute of the solution
4 offered by the present invention is that the higher the MIPS (Million Instructions Per
5 Second) capacity of the CPU, the smaller percentage of time the CPU will spend
6 performing the decode function. This means that higher performance CPU's will
7 demonstrate even lower power usage when playing compressed music performances,
8 thus saving even more battery power and further extending the length of time that the
9 battery maintains sufficient charge to power the portable computer.

10 The mini-OS monitors the audio control buttons (e.g., play, fast forward,
11 rewind, pause, scan, previous track, next track, first track, last track, fast
12 forward/rewind while listening, audio source/media select (e.g., HDD or CD), etc.).
13 (see Figure 3 (48)) for user actuation through the special purpose circuit (see Figure 3
14 (40)) of the present invention, and communicates user requests to the mini-OS file
15 management software of the present invention. Optionally, a small LCD display (see
16 Figure 3 (34)) can be connected to the special purpose circuit to provide visual status
17 indicators (e.g., Song #, Song titles, track #, Playtime & icons) under control of the
18 mini-OS display management subroutines.

19 The mini-OS power saving software of the present invention primarily
20 manages the usage of the CPU, and the MP3 storage devices such as CD, HDD, and
21 flash media such as SD (Secure Digital) cards, MMC (Multimedia Card), memory
22 stick, and SMC (Smart Media Card), while maintaining the rest of the system,
23 including the memory, corelogic chipsets, in a fully on and functional state.
24 Secondary power saving is applied to other PC subsystems to minimize power usage
25 still further by putting them in an idle state.

26 For example, with a 500 MHz Pentium III CPU having about 225 MIPS of
27 processing power and the decode algorithm requiring about 15 MIPS, the CPU will be
28 operating less than 10% of the time. The other 90-95% of the time the CPU will be in
29 a standby mode that requires only milliamps of current. Alternatively, the CPU can
30 be run at a slower clock speed, which is usually an option provided by most of today
31 CPUs, such as the AMD's Athlon CPU. Similarly the HDD is accessed during the

1 time it takes to fill or refill the RAM. Thus, since the average song takes about 4
2 minutes to play and the RAM holds about 30 songs for 120 Mbytes, and since the
3 HDD needs 1-5 seconds to spin up and only several seconds to load the song play list
4 into RAM, the total access time for the HDD may be 30 seconds out of 120 minutes
5 of play time; a ratio of 1:240, less than 0.5% of full power operating time. These
6 factors add to the power savings gained by using the mini OS of the present invention
7 instead of the full operating system of the portable computer. The result of the overall
8 power consumption of the present invention is very low when the portable computer
9 is in the music play mode, and that directly translates into the battery maintaining a
10 useful charge level for a much longer time than allowed by the prior art. As those
11 skilled in the art will recognize, the compressed music data of this invention may
12 reside on a hard disk, on other magnetic (e.g., tape) media, optical (e.g., CD-ROM)
13 media, flash media (e.g., SD cards, MMC, memory stick, SMC), or any other storage
14 medium.

15 Figure 3 is a generalized overall block diagram of an exemplary system 31
16 consistent with one embodiment of the present invention. The majority of the blocks
17 in system 31 are components known in the art and are generally included in all PC
18 computers for producing sound through the speaker of the computer. Shown here is a
19 system clock 56, which, for simplicity of Figure 3, is not shown connected to the
20 various components that need a clock signal. Additionally, CPU 26 is shown
21 interfacing with North Bridge 28. In turn, North Bridge 28 interfaces with system
22 RAM 30 and South Bridge 32. Then South Bridge 32 interfaces with HDD 36 and
23 CD-ROM 38. Typically South Bridge 32 also interfaces directly with Codec 42
24 through AC_link; however, in the exemplary system 31 shown, special purpose
25 circuit 40 (see discussion of Figure 4 below) is inserted between South Bridge 32 and
26 Codec 42 to enable the playing of compressed digital audio in conjunction with the
27 mini-OS 80 of the present invention from system RAM 30, without affecting the
28 ability to play non-compressed analog audio. In this configuration, the mini-OS 80 is
29 stored in the BIOS, although those skilled in the art will recognize that the mini-OS
30 could alternatively be stored in its own ROM (either within special purpose circuit 40
31 or external to it), a hard disk, or other media. Thus, AC_link₁ from South Bridge 32

1 is coupled to special purpose circuit 40, which performs the decompression function
2 as necessary, and then provides any audio signals to Codec 42 via AC_link₂. Codec
3 42 then performs the usual function on all signals received from special purpose
4 circuit 40 and applies the audio signals to amplifier 44, to be played on speaker 46 or
5 headphones (not shown). In system 31, AC_link₁ looks and behaves like the standard
6 AC_link to South Bridge 32, and AC_link₂ looks and behaves like the standard
7 AC_link to Codec 42, making it appear to those portions of the computer that audio
8 functions are being performed as during normal (i.e., known in the art) audio play,
9 thus having minimal or no impact on the operation of South Bridge 32 and Codec 42.
10 Also shown in Figure 3 are function switches 48, small LCD display 34 and audio
11 player power switch 54, which function as described hereinbelow with reference to
12 Figure 4.

13 Figure 4 includes a detailed block diagram of the internals of special purpose
14 circuit 40 and related details of the other portions of the computer that the special
15 purpose circuit interfaces without showing all of the details of the rest of the
16 computer system. Special purpose circuit 40 may be produced as an IC to minimize
17 the PCB space needed to incorporate embodiments of the present invention into
18 portable computers. South Bridge 32 is shown with the standard AC 97 controller 50
19 and LPC (low pin count) controller 52 to the left of special purpose circuit 40 with the
20 standard bidirectional links AC_link₁ and LPC Bus between them, and the
21 unidirectional IRQ (Interrupt Request) link from special purpose circuit 40 to South
22 Bridge 32. To the right, special purpose circuit 40 provides uncompressed audio to
23 AC 97 Codec 42 via AC_link₂. Also, to the right, function keys 48, and below LCD
24 34, are each shown connected to special purpose circuit 40. Additionally, Figure 4
25 includes system clock 56 connected to various components, and in the lower left,
26 audio player power switch 54. Power switch 54 is provided so that when the user
27 initiates the player mode via power switch 54, only the mini-OS (instead of the full
28 system OS) is initiated, for use in a system consistent with the present invention.

29 Internal to special purpose circuit 40 are switches 60 that interface with both
30 AC_link₁ and AC_link₂ and function in response to settings in an internal register of
31 register block 66, with switches 60 closed connecting AC-link₁ with AC_link₂ when

1 the PC functions normally with the full system OS, and with switches 60 open when a
2 system consistent with the present invention is employed. The LPC path is coupled to
3 LPC interface. Switches 60 and AC_link₂ are coupled to state machine 64, while
4 another port of state machine 64 is coupled, via bus 74, to the output of LPC interface
5 62, as well as register block 66, function key interface 68 and LCD interface 72. A
6 second port of register block 66 is also coupled to a third port of state machine 64.
7 Function keys 48 are coupled to function key interface 68, and LCD 34 is coupled to
8 LCD interface 72. Also, function key interface 68 provides a signal to register block
9 66 when one of the function keys 48 is selected by the user. Audio player power
10 switch 54, which is operated by the user in the second step discussed above, may be
11 used to activate the PC to operate as described hereinabove. Switch 54 is shown
12 connected to the DC voltage source of the portable computer and not to any particular
13 block in Figure 4, since that connection varies depending on several factors controlled
14 by the manufacturer of the computer on which an embodiment of the present
15 invention is installed.

16 More specifically, the blocks within special purpose circuit 40 operate as
17 follows:

18 LPC Interface

19 Special purpose circuit 40 includes LPC (Low Pin Count) interface 62 to
20 interface with LPC controller 52 in South Bridge 32.

21 The LPC interface 62 is used to by CPU 26 to:

- 22 (1) read the function key input registers in register block 66;
- 23 (2) set the control register in register block 66 to control the AC97
24 Codec 42;
- 25 (3) get the audio PCM (Pulse Code Modulation) data from the
26 system memory (RAM 30); and
- 27 (4) perform clock throttling control.

28 The setting in the mode register of register block 66 controls the state of
29 switches 60 to switch the special purpose circuit 40 between the normal computer
30 operation mode with switches 60 closed (e.g., running Microsoft Windows® OS) and
31 the mode of a system consistent with the present invention, with switches 60 open

1 (running the mini-OS) to play compressed audio files.

2 **South Bridge AC97 Controller 50 interface (AC Link₁ from host)**

3 During the normal computer operation mode, switches 60 are closed with the
4 South Bridge AC97 Controller 50 interface connected directly through, closed
5 switches 60, to AC97 Codec 42 to generate audio output as if special purpose circuit
6 40 were not present. To play compressed audio files, switches 60 are open when the
7 mini-OS is running, and state machine 64 controls AC97 Codec 42.

8 **AC97 Codec interface (AC Link₂ to AC97 Codec 42)**

9 When the computer is running under control of the mini-OS, switches 60 are
10 open. State machine 64 then controls the AC_link₂ in response to the settings of the
11 register block 66 set by the host (CPU 26) to generate the controls for AC97 Codec 42
12 (e.g., switching the sampling frequency, controlling volume, sending the PCM data to
13 the Codec 42, setting the Codec 42 to the power saving mode or waking Codec 42
14 from the power saving mode).

15 **Function Key Input Interface 68**

16 Function key interface 68 receives the user selections from function keys 48
17 and stores the selections in internal registers to be read by CPU 26.

18 **LCD interface 72**

19 LCD interface 72 is only necessary if LCD 34 is used to provide status
20 information to the user. The purpose, when used, is to show player status on low cost
21 LCD 34 when the system consistent with the present invention is used. Status of the
22 audio track number of the selection playing, status icons (e.g., Play) and other generic
23 status icons may be programmed into the system and displayed for any other purpose.

24 **Operation Modes**

25 **(A) Normal Operation Mode:**

26 When the PC is fully powered and running under the full system OS, the
27 various functions of special purpose circuit 40 are bypassed and switches 60 are
28 closed, as discussed above. In the normal mode, the computer system uses the South
29 Bridge AC97 Controller 50 to directly control the AC97 Codec 42 through the
30 AC_link (in the Normal mode AC_link₁ and AC_link₂ are the same since switches 60
31 are closed. The special purpose circuit does not intercept or modify the AC_link

1 signals.

2 **(B) Compressed Audio Performance Mode:**

3 When switch 54 has been closed, the system runs under the control of mini-
4 OS, and special purpose circuit 40 is empowered and runs in the compressed audio
5 performance mode. The South Bridge AC97 Controller 50 is isolated from the AC97
6 Codec 42 in this mode since switches 60 are open.

7 In the compressed audio performance mode, the host (CPU 26) sets the
8 internal registers of register block 66 to control the data flow to the AC97 Codec 42,
9 and to perform the various power management functions.

10 **A Power Saving Control Method in Compressed Audio Performance Mode**

11 A flexible control method of the special purpose circuit 40 is provided to
12 minimize the system control cycles and power consumption in the performance mode.

13 The system memory (RAM 30) is used to pass most of the control commands to the
14 special purpose circuit 40, instead of CPU 26, which minimizes the time that CPU 26
15 needs to access high speed external bus other than a standby level. This considerably
16 reduces the power load on the portable computer battery in this mode.

17 CPU 26 also sets the system control memory registers in register block 66.
18 State machine 64 bases operation on those register settings to obtain control words
19 and PCM data automatically through the LPC interface 62. The control words in the
20 system memory (RAM 30) are fetched into the internal registers, and the state
21 machine 64 decodes the control words to determine if PCM or audio data is ready. If
22 the audio data is ready, the state machine 64 continues to fetch the audio data and
23 send it to the AC97 Codec 42. The control words in the system memory (RAM 30)
24 can also be used to indicate the sampling frequency of the PCM data. So, the state
25 machine 64 can set AC97 Codec 42 to the appropriate frequency before the PCM data
26 is sent.

27 Those skilled in the art will recognize that a headphone or headset system may
28 comprise further functionality than described hereinabove, e.g., a volume control, or
29 the audio control buttons may be integrated thereto.

30 It should also be recognized that a special purpose circuit consistent with the
31 invention may be integrated into a full-time compressed (and/or non-compressed)

1 audio playing system capable of playing music regardless of the operation of the rest
2 of the system. In this configuration, the special purpose circuit and mini-OS are
3 provided, as well as a software driver for handling interrupts from the function
4 buttons under Windows®. In this configuration, when the rest of the system is either
5 fully on (S0) or in "sleep" (suspend to RAM or S3) mode, the system may be
6 configured to begin execution of a custom or standard audio player, e.g., Music
7 Match or Windows® Media Player, running under Windows®, which may be adapted
8 to play the compressed audio files stored in the play list. In this scenario, the function
9 buttons may be adapted for use in a passthrough-type mode using the accompanying
10 software driver to control various features of the audio player software, e.g., Music
11 Match, instead of controlling the special purpose circuit. When the primary operating
12 system such as Windows® is either fully off (S5) or in "hibernate" (suspend to HDD
13 or S4) mode, operation of the special purpose circuit may proceed to play compressed
14 audio files from the play list as described hereinabove, wherein the function buttons
15 control the special purpose circuit.

16 It is noted that the power states described above (i.e., fully on, sleep/suspend
17 to RAM, fully off, hibernate/suspend to HDD) are often referred to using the
18 Advanced Configuration and Power Interface ("ACPI") standard conventions, as
19 follows: The typical operating system (e.g., Windows®) supports six system power
20 states, referred to as S0 (fully on and operational) through S5 (power off). Each state
21 is characterized by the following: power consumption, i.e. how much power the
22 computer uses; software resumption, i.e. from what point the operating system
23 restarts; hardware latency, i.e., how long it takes to return the computer to the
24 working state; and system context, i.e. how much system context is retained, or
25 whether the operating system must reboot to return to the working state. State S0 is
26 the working state. States S1, S2, S3, and S4 are sleeping states, in which the computer
27 appears off because of reduced power consumption but retains enough context to
28 return to the working state without restarting the operating system. State S5 is the
29 shutdown or off state. A system is waking when it is in transition from the shutdown
30 state (S5) or any sleeping state (S1-S4) to the working state (S0), and it is going to
31 sleep when it is in transition from the working state to any sleep state or the shutdown

1 state. the system cannot enter one sleep state directly from another; it must always
2 enter the working state before entering any sleep state. For example, a system cannot
3 transition from state S2 to S4, nor from state S4 to S2. It must first return to S0, from
4 which it can enter the next sleep state. Because a system in an intermediate sleep state
5 has already lost some operating context, it must return to the working state to restore
6 that context before it can make an additional state transition.

7 Referring now to Figure 2, in conjunction with Figure 3, an exemplary
8 sequence 200 for the power up of the mini-OS and initiation of the player function, in
9 one embodiment of the present invention, is illustrated. As stated above, at some time
10 prior to the initiation of the audio player function of a PC equipped with the present
11 invention, the user downloads (not shown in Figure 2) the audio files of interest to the
12 HDD 36 or burns a CD-ROM that is placed in the CD-ROM drive 38 for use with the
13 audio player feature of the present invention. As shown, at step 201, the sequence
14 200 begins when the user presses either an audio player power switch 54 or the
15 computer's main power switch (not shown in Figure 3), to turn the system on. A
16 determination is then made, at step 202, whether the computer is to boot in normal
17 operation mode or compressed audio performance mode. This determination is
18 typically made in the BIOS, based on whether the computer's power switch or an
19 audio player power switch 54 was used to turn on the computer, although those
20 skilled in the art will recognize that this determination could alternatively be made by
21 an application program or an operating system that provides such capability (e.g.,
22 Windows® 98). If the computer's power switch was used to turn on the computer,
23 then the system boots to normal operation mode, at step 203, and the normal
24 operating system (e.g., Windows® 98) is loaded into system RAM 30 and executed. If
25 an audio player power switch 54 was used to turn on the computer, the mini-OS is
26 loaded into system RAM 30, at step 204. At step 203, the mini-OS initializes the
27 system components including one or more of the North Bridge 28, South Bridge 32,
28 special purpose circuit 40, hard drive 36, CD-ROM drive 38, codec 42, and CPU 26.
29 Since no audio decompression request will be pending upon system
30 initialization (i.e., the memory buffer is not full), which determination is made at step
31 208, the system waits for input from one of the function keys 48, at step 207, until one

1 of the function keys 48 is pressed, at which point the appropriate function is executed
2 and the LCD display updated, as appropriate, at step 206. If the command includes a
3 request from the user to play audio, an audio decompression request will be pending
4 at this time, which determination is made at step 208. Since no compressed audio
5 file(s) are in system memory 30 upon the initial request to play audio, which
6 determination is made at step 209, the compressed audio file(s) are read from the
7 HDD 36 and/or CD-ROM drive 38 and loaded into system memory 30, at step 210.
8 After the compressed audio files are loaded into system memory at step 210, or if the
9 audio file(s) are already in system memory, which determination is made at step 209,
10 the audio files are then decompressed, at step 211, using the system CPU 26. DMA
11 transfer(s) to the codec 42 are initialized for the decompressed audio data, at step 212,
12 and then the output signal from the Codec 42 is amplified (not shown in Figure 2) by
13 the amplifier 44 to drive the speakers and/or headset 46. After the DMA transfer(s)
14 are initialized, at step 212, control loops back to step 208, to determine whether an
15 audio decompression request is pending.

16 Playlist Software Operation

17 Figure 5 is another generalized overall block diagram of an exemplary system
18 31 consistent with another embodiment of the present invention. In this exemplary
19 embodiment, the system 31 includes portable memory media 80 that can be used to
20 hold the playlist data and/or compressed file data. The memory media 80 can be
21 SmartCard media, Memory Stick media, PCMCIA memory media and/or other
22 portable media known in the art. If the system is ON and media is detected as being
23 present at the portable memory media location (e.g., by insertion of a Smart Card,
24 PCMCIA, CardBus card, Memory Stick or other media into an appropriate slot), the
25 memory reader generates an interrupt to the South Bridge 32. The special purpose
26 circuit 40 of this embodiment also receives the interrupt and generates a command to
27 tell the operating system to launch an appropriate application (e.g., Windows Media
28 Player) to read the playlist data on the memory device 80. In this instance, the
29 application takes control to read the playlist file and retrieve the audio data, either
30 from the memory device 80 or some other location specified in the playlist file.
31 Similarly, when the mini-OS is operational, the special purpose circuit 40 is adapted

1 to check if a memory device 80 is present, and to scan the device for playlist data.

2 The system then operates as described above.

3 The playlist file, as described herein, is a generalized data file that is
4 constructed by a user having a desired MP3 song sequence. The playlist file also
5 includes disk path information to instruct the application as to where to locate the
6 desired MP3 data. Certain operating systems permit users to change drive letters on-
7 the-fly. Accordingly, the playlist software reads the volume serial number (VSN)
8 given by the operating system to a particular drive. The serial number does not
9 change (unless intentionally changed by reformatting the drive), and thus, the playlist
10 software can track the playlist data regardless if the user reassigns a particular drive
11 letter. This feature also works similarly with switchable devices such as disk drives.

12 It should be recognized by those skilled in the art that, although the above-
13 described embodiments utilize a hardware-based OS selection (i.e., pressing main
14 power button boots to Windows®, while pressing audio control button boots to mini-
15 OS), other OS selection methods are contemplated, as well. Such selection methods
16 include, e.g., using a batch file or other scripting or software-based method to shut
17 down a first OS and boot to the second OS. Those skilled in the art will also
18 recognize that the mini-OS of the present invention could conceivably be
19 implemented as part of a larger OS (e.g., a GUI-based OS, such as Windows®,
20 LINUX, etc.) or as a software component named something other than an "operating
21 system", (e.g., a "driver", an "algorithm", a "script", "code", a "program", an
22 "executable", a "routine", a "subroutine", a "utility", etc.), instead of being
23 implemented as an entirely separate operating system. Such embodiments are
24 contemplated to be within the scope of the present invention.

25 Although the present invention has been described in terms of the exemplary
26 embodiments provided herein, it is to be understood that such disclosure is purely
27 illustrative and is not to be interpreted as limiting. Consequently, without departing
28 from the spirit and scope of the invention, various alterations, modifications, and/or
29 alternative applications of the invention will, no doubt, be suggested to those skilled
30 in the art after having read the preceding disclosure. Accordingly, it is intended that
31 the following claims be interpreted as encompassing all alterations, modifications, or

1 alternative applications as fall within the true spirit and scope of the invention.

2

1 What is claimed is:

2 1. A computer system adapted to play audio files, said computer system
3 comprising:

4 a system CPU;
5 memory;
6 at least one drive comprising compressed audio data, said
7 compressed audio data residing in one or more audio files;
8 a play list software program for selecting and storing a play list
9 comprising one or more of said audio files;
10 a first operating system adapted to control at least said system
11 CPU and said memory; and
12 a second operating system, said second operating system being
13 stored in BIOS and adapted to retrieve said play list and cause said drive to read at
14 least one said audio file of said play list, to cause said system CPU to decompress
15 the compressed audio data of said file and provide decompressed audio data, and
16 to cause said decompressed audio data to be stored in said memory.

17 2. A computer system adapted to play audio files, said computer system
18 comprising:

19 a system CPU;
20 memory;
21 at least one drive comprising compressed audio data;
22 a first operating system adapted to control at least said system
23 CPU and said memory; and
24 a second operating system, said second operating system being
25 stored in BIOS and adapted to cause said system CPU to decompress said compressed
26 audio data and store said decompressed audio data in said memory.

27 3. A computer system adapted to play audio files, said computer system
28 comprising:

29 a system CPU;
30 memory;
31 at least one drive comprising compressed audio data; and

1 an operating system stored in BIOS, said operating system
2 being adapted to cause said system CPU to decompress said compressed audio
3 data and store said compressed audio data in said memory.

4 4. A computer system adapted to play audio files, said computer system
5 comprising:

6 compressed audio data;

7 a system CPU; and

8 an operating system stored in BIOS, said operating system
9 being adapted to cause said system CPU to decompress said compressed audio
10 data.

11 5. A computer system adapted to play audio files, said computer system
12 comprising:

13 compressed audio data;

14 a system CPU;

15 an audio controller; and

16 an operating system stored in BIOS, said operating system
17 controlling said audio controller and said system CPU, so as to cause said system
18 CPU to decompress said compressed audio data.

19 6. A computer system adapted to play audio files, said computer system
20 comprising:

21 compressed audio data;

22 a system CPU;

23 an audio controller;

24 a first operating system adapted to control at least said system
25 CPU; and

26 a second operating system stored in BIOS, said second
27 operating system controlling said audio controller and said system CPU, so as to
28 cause said system CPU to decompress said compressed audio data.

29 7. A computer system adapted to play audio files, said computer system
30 comprising:

31 a system CPU;

- 1 memory;
2 at least one drive comprising compressed audio data, said
3 compressed audio data residing in one or more audio files;
4 a first operating system adapted to control at least said system
5 CPU and said memory;
6 a play list software program executable under said first
7 operating system, said play list software program being adapted to permit
8 selection and storage of a play list comprising one or more of said audio files; and
9 a second operating system, said second operating system being
10 stored in BIOS and adapted to retrieve said play list and cause said drive to read at
11 least one said audio file of said play list, to cause said system CPU to decompress
12 the compressed audio data of said file and provide decompressed audio data, and
13 to cause said decompressed audio data to be stored in said memory.
- 14 8. A computer system adapted to play audio files, said computer system
15 comprising:
16 at least one drive comprising audio data, said audio data
17 residing in one or more audio files;
18 a system CPU;
19 memory;
20 a first operating system adapted to control at least said system
21 CPU and said memory;
22 a play list software program executable under said first
23 operating system, said play list software program being adapted to permit
24 selection and storage of a play list comprising one or more of said audio files; and
25 a second operating system, said second operating system being
26 stored in BIOS and adapted to retrieve said play list and cause said drive to read at
27 least one said audio file of said play list, and to play said at least one said audio
28 file of said play list.
- 29 9. A computer system adapted to play audio files, said computer system
30 comprising:
31 a drive comprising at least one audio file;

1 an audio controller; and
2 an operating system stored in BIOS, said operating system controlling said
3 audio controller, so as to cause said audio controller to play said at least one audio
4 file.

5 10. A computer system adapted to play audio files, said computer system
6 comprising:
7 a system CPU;
8 a drive comprising at least one compressed audio file; and
9 an operating system stored in BIOS, said operating system controlling said
10 system CPU, so as to cause said system CPU to decompress said at least one
11 audio file.

12 11. A method of playing audio files on a computer system, said method
13 comprising:
14 booting a first operating system;
15 creating and storing a play list comprising a list of compressed audio files
16 residing on one or more drives of a computer system having at least a drive, a
17 CPU, and a memory;
18 terminating said first operating system;
19 booting a second operating system upon activation by a switch;
20 reading said play list;
21 reading said compressed audio files from said drive based on said play list;
22 providing said compressed audio data to said CPU for decompressing the
23 data of said compressed audio file into decompressed audio data;
24 storing said decompressed audio data in said memory; and
25 retrieving said decompressed audio data from said memory for playing.

26 12. A method of playing audio files on a computer system, said method
27 comprising:
28 booting a first operating system;
29 creating and storing a play list comprising a list of compressed audio files
30 residing on one or more drives of a computer system having at least a drive, a
31 CPU, and a memory;

- 1 terminating said first operating system;
2 booting a second operating system;
3 reading said play list;
4 reading said compressed audio files from said drive based on said play list;
5 providing said compressed audio data to said CPU for decompressing the
6 data of said compressed audio file into decompressed audio data;
7 storing said decompressed audio data in said memory; and
8 retrieving said decompressed audio data from said memory for playing.
- 9 13. A computer system adapted to play audio files, said computer system
10 comprising:
11 a system CPU;
12 memory;
13 at least one drive comprising compressed audio data;
14 a first operating system adapted to control at least said system
15 CPU and said memory;
16 a second operating system, said second operating system being
17 adapted to cause said system CPU to decompress said compressed audio data and
18 store said decompressed audio data in said memory;
19 a first switch, the activation of said first switch causing said
20 first operating system to boot; and
21 a second switch, the activation of said second switch causing
22 said second operating system to boot.
- 23 14. A computer system adapted to play audio files, said computer system
24 comprising:
25 a system CPU;
26 memory;
27 a first operating system adapted to control at least said system
28 CPU and said memory;
29 at least one drive comprising compressed audio data;
30 a second operating system, said second operating system being
31 adapted to cause said system CPU to decompress said compressed audio data and

- 1 store said compressed audio data in said memory; and
2 a switch, the activation of said switch causing said second
3 operating system to boot.
- 4 15. A computer system adapted to play audio files, said computer system
5 comprising:
6 compressed audio data;
7 a system CPU;
8 a first operating system adapted to control at least said system
9 CPU and said memory;
10 a second operating system, said second operating system being
11 adapted to cause said system CPU to decompress said compressed audio data; and
12 a switch, the activation of said switch causing said second
13 operating system to boot and cause said system CPU to decompress said
14 compressed audio data.
- 15 16. A computer system adapted to play audio files, said computer system
16 comprising:
17 compressed audio data;
18 a system CPU;
19 an audio controller;
20 a first operating system adapted to control at least said system
21 CPU and said memory;
22 a second operating system, said second operating system
23 controlling said audio controller and said system CPU, so as to cause said system
24 CPU to decompress said compressed audio data; and
25 a switch, the activation of said switch causing said second
26 operating system to boot.
- 27 17. A computer system adapted to play audio files, said computer system
28 comprising:
29 compressed audio data;
30 a system CPU;
31 an audio controller;

- 1 a first operating system adapted to control at least said system
2 CPU;
- 3 a second operating system, said second operating system
4 controlling said audio controller and said system CPU, so as to cause said system
5 CPU to decompress said compressed audio data; and
6 a switch, the activation of said switch causing said second
7 operating system to boot.
- 8 18. A computer system adapted to play audio files, said computer system
9 comprising:
- 10 a drive comprising at least one audio file;
11 an audio controller;
12 an operating system, said operating system being stored in BIOS and
13 adapted to control said audio controller, so as to cause said audio controller to
14 play said at least one audio file; and
15 a switch, the activation of said switch causing said operating system to
16 boot.
- 17 19. A computer system adapted to play audio files, said computer system
18 comprising:
- 19 a system CPU;
20 a drive comprising at least one compressed audio file; and
21 an operating system, said operating system being stored in BIOS and
22 adapted to control said system CPU, so as to cause said system CPU to
23 decompress said at least one audio file; and
24 a switch, the activation of said switch causing said operating system to boot.
- 25 20. A computer system adapted to play audio files, said computer system
26 comprising:
- 27 a system CPU;
28 memory;
29 at least one drive comprising compressed audio data; and
30 an audio controller coupled to said system CPU, memory and
31 drive;

1 said audio controller being adapted to cause said drive to read
2 said compressed audio data, to cause said system CPU to decompress said
3 compressed audio data, thereby providing decompressed audio data, and to cause
4 said decompressed audio data to be stored in said memory.

5

6 21. A computer system as claimed in claim 20, wherein said audio controller
7 is further adapted to place said system CPU in standby state when said system CPU is
8 not decompressing said compressed audio data.

9 22. A computer system as claimed in claim 20, wherein said audio controller
10 is further adapted to cause said decompressed audio data to be retrieved from said
11 memory for playing.

12 23. A computer system as claimed in claim 20, wherein said drive is a hard
13 disk, removable disk, floppy disk, magnetic storage medium, optical storage medium,
14 or IDE device.

15 24. A computer system as claimed in claim 20, wherein said compressed audio
16 data is in MP3, WMA, AAC, or other secured compressed audio format.

17 25. A computer system as claimed in claim 20, further comprising at least one
18 digital computer bus, wherein said audio controller is coupled to at least one of said
19 system CPU, memory, and drive via said digital computer bus.

20 26. A computer system as claimed in claim 20, further comprising a mini-OS.

21 27. A computer system as claimed in claim 20, further comprising an LCD
22 interface for generating signals to an LCD display for displaying song name,
23 file/directory name and/or timing data.

24 28. A computer system as claimed in claim 20, further comprising a plurality
25 of function keys and a function key interface operable with said plurality of function
26 keys, said function keys generating user commands to said audio controller through
27 said function key interface.

28 29. A computer system as claimed in claim 28, further comprising a software
29 driver for receiving interrupts generated by at least one of said plurality of function
30 keys and for passing said interrupts to said system CPU.

31 30. A computer system as claimed in claim 29, further comprising standard

1 audio player software, wherein said CPU utilizes said interrupts to control said
2 standard audio player software.

3 31. A computer system as claimed in claim 20, wherein said audio controller
4 is adapted not to cause said drive to read said compressed audio data, nor to cause
5 said system CPU to decompress said compressed audio data, nor to cause said
6 decompressed audio data to be stored in said memory, unless said computer system is
7 off, in hibernate mode, in suspend to HDD mode, or in one of power states S4 or S5.

8 32. A computer system as claimed in claim 20, wherein said audio controller
9 is adapted not to cause said drive to read said compressed audio data, nor to cause
10 said system CPU to decompress said compressed audio data, nor to cause said
11 decompressed audio data to be stored in said memory, when said computer system is
12 on, in sleep mode, in suspend to RAM mode, or in one of power states S0 or S3.

13 33. A computer system as claimed in claim 29, wherein said software driver is
14 adapted not to receive said interrupts generated by at least one of said plurality of
15 function keys nor pass said interrupts to said system CPU, unless said computer
16 system is on, in sleep mode, in suspend to RAM mode, or in one of power states S0 or
17 S3.

18 34. A computer system as claimed in claim 20, wherein said compressed audio
19 data is stored in one or more audio files on said drive, said computer system further
20 comprising a play list software program for creating and storing a play list comprising
21 one or more said audio files.

22 35. A computer system as claimed in claim 34, wherein said play list software
23 program is executable only when said computer is on or in power state S0.

24 36. A computer system as claimed in claim 35, wherein said audio controller
25 is further adapted to cause said drive to read said compressed audio data based, at
26 least in part, on said stored play list.

27 37. A computer system adapted to play audio files, said computer system
28 comprising:

29 a system CPU;

30 memory;

31 at least one drive comprising compressed audio data, said

1 compressed audio data residing in one or more audio files;
2 a play list software program for selecting a play list comprising
3 one or more of said audio files; and
4 an audio controller coupled to said system CPU, memory and
5 drive;
6 said audio controller being adapted to cause said drive to read
7 at least one said audio file of said play list, to cause said system CPU to
8 decompress the compressed audio data of said file and thereby provide
9 decompressed audio data, and to cause said decompressed audio data to be stored
10 in said memory.

11 38. A method of playing audio files on a computer system, said method
12 comprising:

13 reading compressed audio data from the drive of a computer system
14 having at least a drive, a CPU, and a memory;
15 providing said compressed audio data to said CPU for decompressing
16 said compressed audio data, thereby providing decompressed audio data; and
17 storing said decompressed audio data in said memory.

18 39. A method of playing audio files on a computer system as claimed in claim
19 38, further comprising placing said system CPU in a standby state when said system
20 CPU is not decompressing said compressed audio data.

21 40. A method of playing audio files on a computer system as claimed in claim
22 38, further comprising retrieving said decompressed audio data from said memory for
23 playing.

24 41. A method of playing audio files on a computer system as claimed in claim
25 38, wherein said drive is a hard disk, removable disk, floppy disk, magnetic storage
26 medium, optical storage medium, flash media, or IDE device.

27 42. A method of playing audio files on a computer system as claimed in claim
28 38, wherein said compressed audio data is in MP3, WMA, AAC, or other secured
29 compressed audio format.

30 43. A method of playing audio files on a computer system as claimed in claim
31 38, further comprising generating signals to an LCD display for displaying song

1 name, file/directory name and/or timing data.

2 44. A method of playing audio files on a computer system as claimed in claim
3 38, wherein said computer system further comprises a plurality of function keys, and
4 wherein said method further comprises receiving user commands generated by at least
5 one of said plurality of function keys and utilizing said user commands to control said
6 playing.

7 45. A method of playing audio files on a computer system as claimed in claim
8 38, further comprising receiving interrupts generated by at least one of said plurality
9 of function keys and passing said interrupts to said system CPU.

10 46. A method of playing audio files on a computer system as claimed in claim
11 38, wherein said computer system further comprises standard audio player software,
12 and wherein said method further comprise utilizing said interrupts to control said
13 standard audio player software.

14 47. A method of playing audio files on a computer system as claimed in claim
15 38, wherein said steps of reading compressed audio data from the drive of said
16 computer system, providing said compressed audio data to said CPU, and storing said
17 decompressed audio data in said memory, are not performed unless said computer
18 system is off, in hibernate mode, in suspend to HDD mode, or in one of power states
19 S4 or S5.

20 48. A method of playing audio files on a computer system as claimed in claim
21 20, wherein said steps of reading compressed audio data from the drive of said
22 computer system, providing said compressed audio data to said CPU for
23 decompressing said compressed audio data into said decompressed audio data, and
24 storing said decompressed audio data in said memory, are not performed when said
25 computer system is on, in sleep mode, in suspend to RAM mode, or in one of power
26 states S0 or S3.

27 49. A method of playing audio files on a computer system as claimed in claim
28 45, wherein said steps of receiving interrupts generated by at least one of said
29 plurality of function keys and passing said interrupts to said system CPU are not
30 performed unless said computer system is on, in sleep mode, in suspend to RAM
31 mode, or in one of power states S0 or S3.

1 50. A method of playing audio files on a computer system as claimed in claim
2 20, wherein said compressed audio data is stored in one or more audio files on said
3 drive, wherein said method further comprises creating and storing a play list
4 comprising one or more said audio files.

5 51. A method of playing audio files on a computer system as claimed in claim
6 50, wherein said step of creating and storing a play list is only performed when said
7 computer is on or in power state S0.

8 52. A method of playing audio files on a computer system as claimed in claim
9 51, further comprising reading said compressed audio data from said drive based, at
10 least in part, on said play list.

11 53. A method of playing audio files on a computer system, said method
12 comprising:
13 creating and storing a play list comprising a list of compressed audio files
14 residing on one or more drives of a computer system having at least a drive, a CPU,
15 and a memory;
16 reading said play list;
17 reading said compressed audio files from said drive based on said play list;
18 providing said compressed audio data to said CPU for decompressing the
19 data of said compressed audio file into decompressed audio data;
20 storing said decompressed audio data in said memory; and
21 retrieving said decompressed audio data from said memory for playing.

22 54. A method of playing audio files on a computer system, said method
23 comprising:
24 when said computer system is on, in sleep mode, in suspend to RAM mode,
25 or in one of power states S0 or S3, creating and storing a play list comprising a list of
26 compressed audio files residing on one or more drives of a computer system having at
27 least a drive, a CPU, and a memory; and
28 when said computer system is off, in hibernate mode, in suspend to HDD
29 mode, or in one of power states S4 or S5, playing the compressed audio files of said
30 play list.

31 55. A method of playing audio files on a computer system, said method

1 comprising:

2 when said computer system is on, in sleep mode, in suspend to RAM mode,
3 or in one of power states S0 or S3, creating and storing a play list comprising a list of
4 compressed audio files residing on one or more drives of a computer system having at
5 least a drive, a CPU, and a memory;

6 when said computer system is off, in hibernate mode, in suspend to HDD
7 mode, or in one of power states S4 or S5, reading said play list;

8 when said computer system is off, in hibernate mode, in suspend to HDD
9 mode, or in one of power states S4 or S5, reading said compressed audio files from
10 said drive based on said play list;

11 when said computer system is off, in hibernate mode, in suspend to HDD
12 mode, or in one of power states S4 or S5, providing said compressed audio data to
13 said CPU for decompressing the data of said compressed audio file into decompressed
14 audio data;

15 when said computer system is off, in hibernate mode, in suspend to HDD
16 mode, or in one of power states S4 or S5, storing said decompressed audio data in
17 said memory; and

18 when said computer system is off, in hibernate mode, in suspend to HDD
19 mode, or in one of power states S4 or S5, retrieving said decompressed audio data
20 from said memory for playing.

21 56. A method of playing audio files on a computer system, said method
22 comprising:

23 reading compressed audio data from the drive of a computer system, said
24 computer system having at least a drive, a CPU, and a memory;

25 providing said compressed audio data to said CPU for decompressing said
26 compressed audio data into decompressed audio data;

27 storing said decompressed audio data in said memory; and

28 playing said decompressed audio data from said memory.

29 57. A computer system adapted to play audio files, said computer system
30 comprising:

31 a system CPU;

1 memory;
2 at least one drive comprising compressed audio data, said compressed
3 audio data residing in one or more audio files;
4 a play list software program for selecting and storing a play list comprising
5 one or more of said audio files; and
6 an audio controller coupled to said system CPU, memory and drive;
7 said audio controller being adapted to retrieve said play list and cause said drive to
8 read at least one said audio file of said play list, to cause said system CPU to
9 decompress the compressed audio data of said file and provide decompressed audio
10 data, to cause said decompressed audio data to be stored in said memory, and to cause
11 said decompressed audio data to be played from said memory.

12 58. A computer system adapted to play audio files, said computer system
13 comprising:

14 a system CPU;
15 memory;
16 at least one drive comprising compressed audio data, said
17 compressed audio data residing in one or more audio files;
18 a play list software program for selecting and storing a play list
19 comprising one or more of said audio files, said play list containing information
20 related to the location of said audio files including the volume serial number of
21 the drive containing said audio file;
22 a first operating system adapted to control at least said system
23 CPU and said memory; and
24 a second operating system, said second operating system being
25 stored in BIOS and adapted to retrieve said play list and cause said drive to read at
26 least one said audio file of said play list, to cause said system CPU to decompress
27 the compressed audio data of said file and provide decompressed audio data, and
28 to cause said decompressed audio data to be stored in said memory.

29 59. A computer system as claimed in claim 58, further comprising a portable
30 memory media device including a portable memory media reader and a portable
31 memory device, wherein said playlist data being stored on said portable memory

1 media.

2 60. A computer system as claimed in claim 59, wherein said portable memory
3 media device selected from the group of Smart Card, PCMCIA, CardBus card and
4 Memory Stick.

5 61. A computer system adapted to play audio files, said computer system
6 comprising:

7 a system CPU;

8 memory;

9 a first drive comprising compressed audio data, said
10 compressed audio data residing in one or more audio files;

11 a play list software program for selecting and storing a play list
12 comprising one or more of said audio files, said play list stored on a second drive
13 comprising portable memory media;

14 a first operating system adapted to control at least said system
15 CPU and said memory; and

16 a second operating system, said second operating system being stored in
17 BIOS and adapted to retrieve said play list and cause said drive to read at least one
18 said audio file of said play list, to cause said system CPU to decompress the
19 compressed audio data of said file and provide decompressed audio data, and to cause
20 said decompressed audio data to be stored in said memory.

21 62. A computer system as claimed in claim 61, said play list containing
22 information related to the location of said audio files including volume serial number
23 of the drive containing said audio file.

24 63. A computer system as claimed in claim 61, said portable memory media
25 device including a portable memory media reader and a portable memory device,
26 wherein said playlist data being stored on said portable memory media.

27 64. A computer system as claimed in claim 63, wherein said portable memory
28 media device selected from the group of Smart Card, PCMCIA, CardBus card and
29 Memory Stick.

30

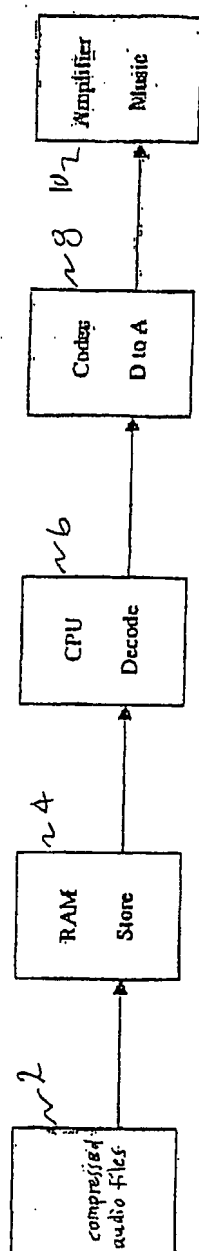
FIGURE 1

FIGURE 2

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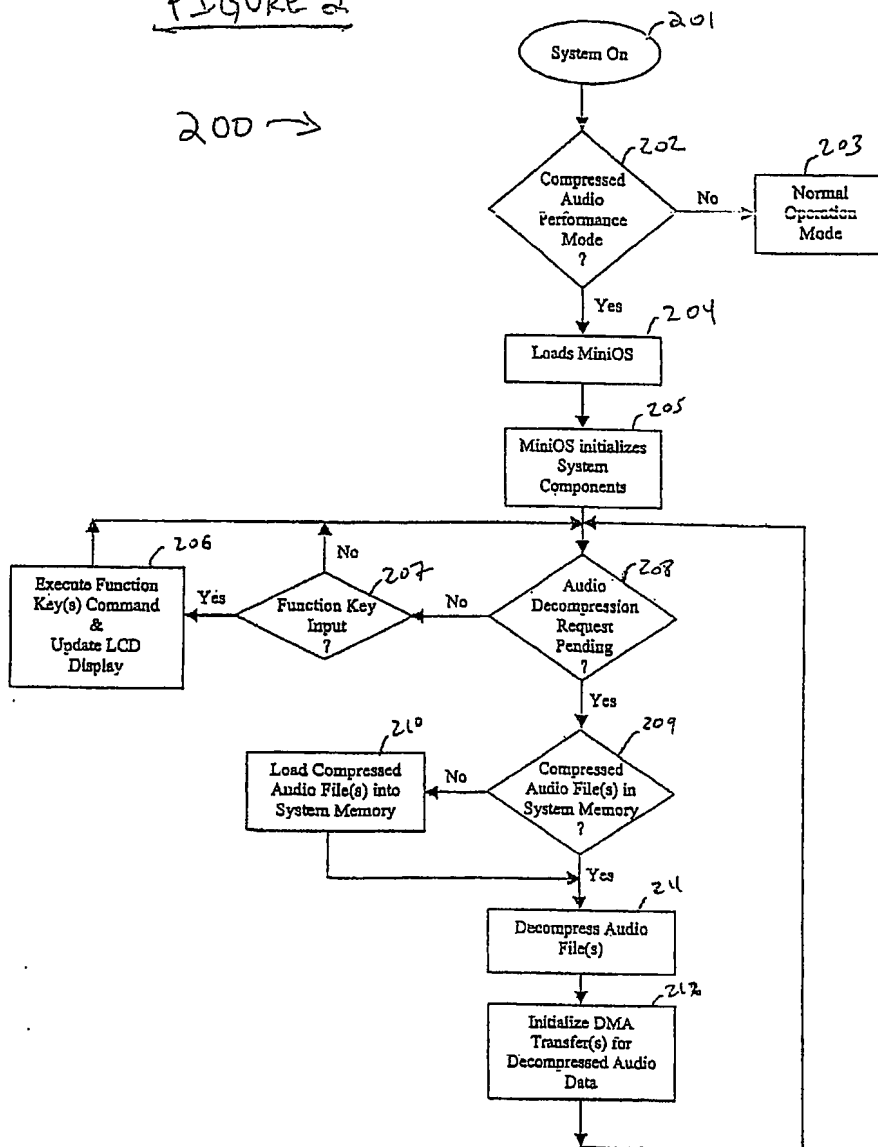
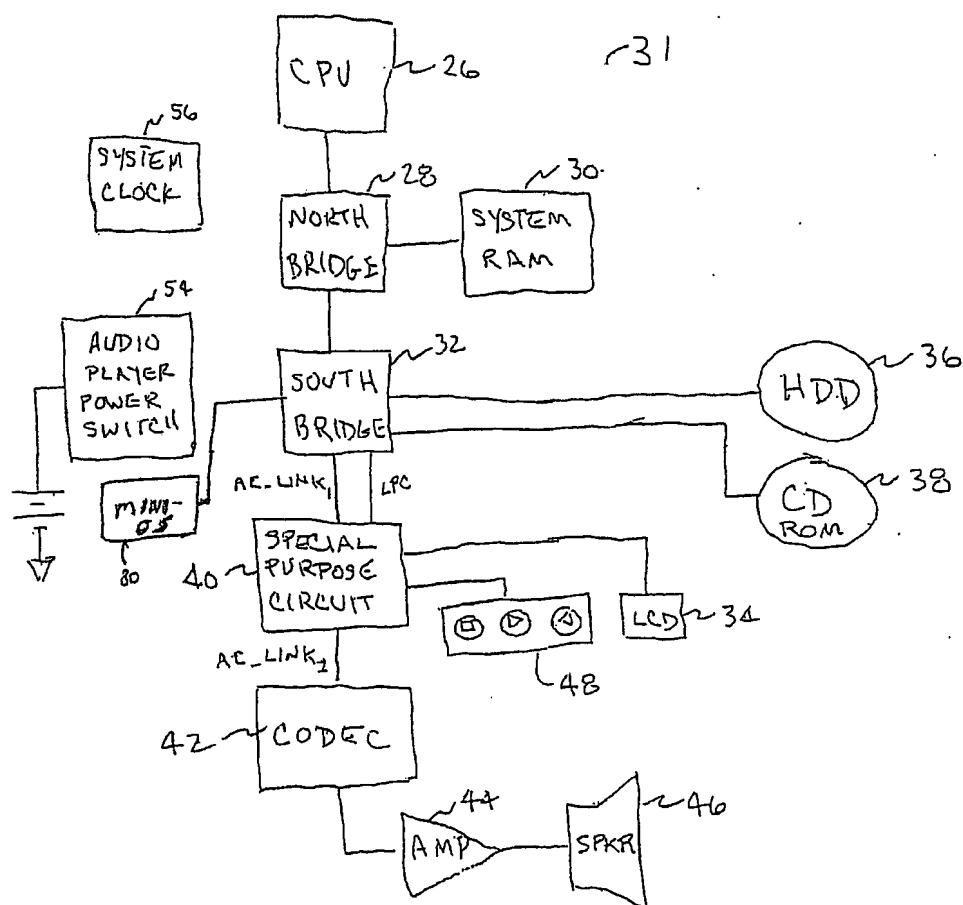


FIGURE 3

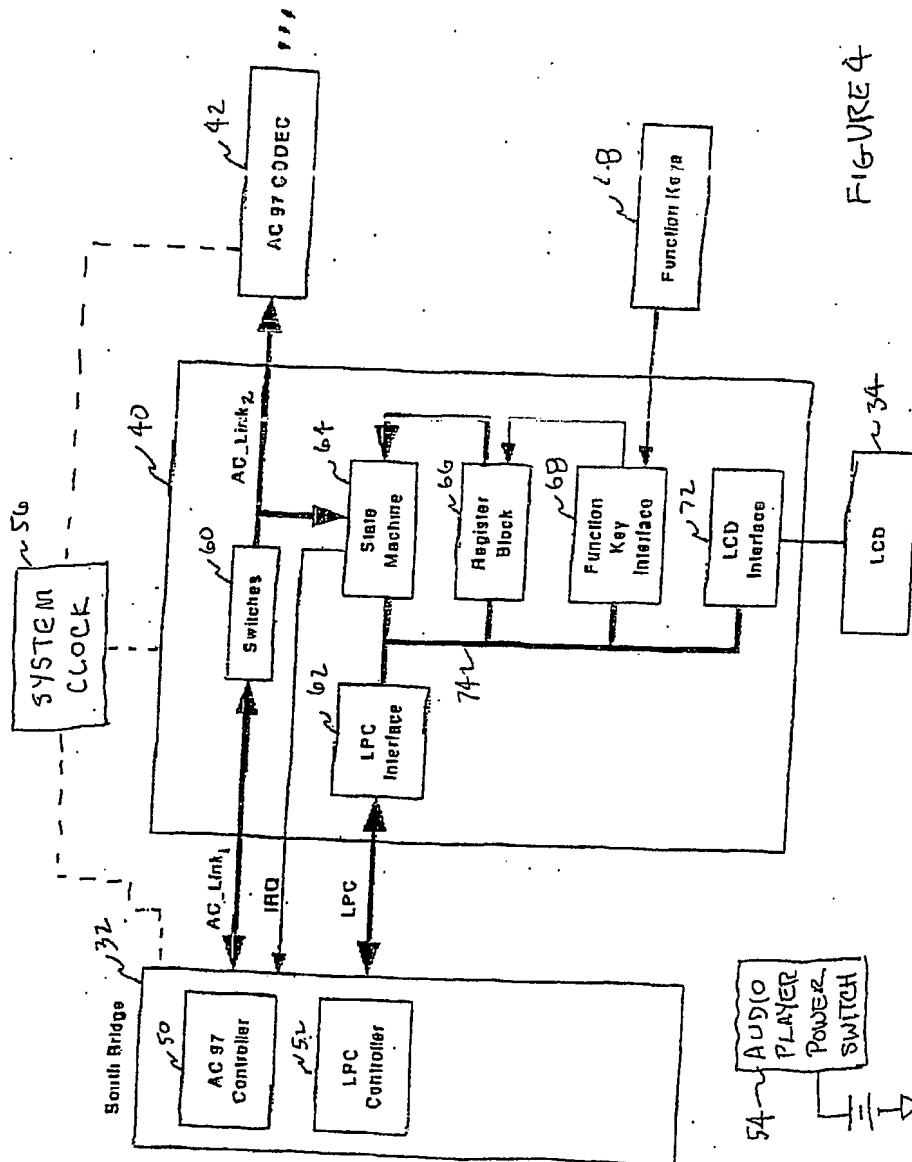


FIGURE 4

FIGURE 5